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REPORT NUMBER 643

**NOISE LEVELS INSIDE NAVY DIVING CHAMBERS
DURING COMPRESSION AND DECOMPRESSION**

by

Thomas Murry

**Bureau of Medicine and Surgery, Navy Department
Research Work Unit MF12.524.004-9010D.10**

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**J. E. Stark, CAPT MC USN
COMMANDING OFFICER
Naval Submarine Medical Center**

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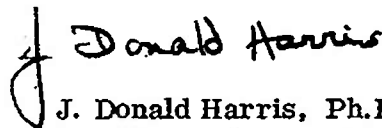
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NAVAL SUBMARINE MEDICAL RESEARCH LABORATORY
NAVAL SUBMARINE MEDICAL CENTER REPORT NO. 643

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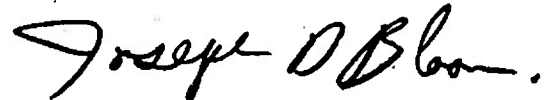
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SUMMARY PAGE

THE PROBLEM

To determine the noise levels during the descending and ascending stages of a dive to 100 feet in compressed air.

FINDINGS

The maximum A-scale readings obtained were 120 dB sound pressure level (SPL) during the descending stage and 115 dB SPL during the ascending stage. The maximum noise level was 113 dB SPL for the octave band of 2400-4800 Hertz during descent. The ascending noise levels within the octave bands were approximately 4-6 dB less than the descending levels.

APPLICATION

The results may be applied to the current damage risk criteria specified by the Bureau of Medicine and Surgery. For dives of the depth investigated, the noise levels are within the allowable limits. The data may be used to predict allowable noise level limits per unit of time for dives to greater depths.

ADMINISTRATIVE INFORMATION

This investigation was conducted under Bureau of Medicine and Surgery Research Work Unit MF12.524.004-9010D -- Optimization of Auditory Performance in Submarines. The present report is No. 10 on this Work Unit. It was approved for publication on 21 October 1970 and designated as NavSubMedResLab Report No. 643.

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ABSTRACT

The noise levels inside diving chambers and submarines have been suggested as a possible contributor to the hearing losses of Navy divers and submariners. In this experiment, sound pressure levels of the noise in a diving chamber were measured during compression and decompression. Several men were situated in a diving chamber which was pressurized to a depth equal to 100 feet of sea water. Two dives were made. In the first, measurements were taken during compression with a piezoelectric microphone oriented so that it was approximately in a horizontal line with the diver's ear and facing away from the intake valve; during the ascent stage, the microphone was facing away from the vent. In the second dive, the microphone was at the same position in the chamber but hanging downward at the diver's ear level. The microphone was previously calibrated under pressure using the reciprocity calibration technique. Measurements were taken with an octave band noise analyzer located outside the chamber. The results indicate that the noise levels were highest in the frequency range between 300 and 4800 Hertz. The results are discussed in relationship to damage risk criteria for Navy personnel.

NOISE LEVELS IN NAVY DIVING CHAMBERS DURING COMPRESSION AND DECOMPRESSION

INTRODUCTION

Recently, CHABA* Working Group 46¹ published guidelines for determining auditory damage risk criteria (DRC). For the protection of Navy personnel exposed to noise, Harris², on the basis of the CHABA Working Group and other information suggested allowable limits for exposure to pure tones, continuous noise, and intermittent noise as measured by sound level meters using the A-Scale or whole octave filters. The Navy's interest in the problems of environmental noise control provided the impetus for the present investigation of noise in a particular environment, namely, the hyperbaric chamber.

Several reports indicate that there are threshold shifts, both temporary and permanent, associated with diving in hyperbaric chambers. Harris³ has summarized the symptoms and etiologies of the hearing losses associated with compression and decompression. Summitt⁴ in personal communication has found that temporary threshold shifts are routinely found in divers noting that the shifts are usually greater when the diver is wearing some type of helmet than when he is in a chamber without a helmet.

Although the noise associated with hyperbaric chambers has often been considered as a contributor to the hearing deficiencies of divers, the problems associated with accurate noise meas-

urement under pressure have made it difficult to make any definite conclusions about the noise levels that occur in these chambers. Moreover, the noise levels vary as depth or speed of descent is changed and as a function of the position of the diver's ear in relation to the intake or exhaust valves.

The present study was procedurally a pilot investigation to determine the noise levels in a hyperbaric chamber down to a simulated depth of 100 feet of sea water (50 lbs/in²).

Prior to this study, it was necessary to obtain a microphone which could tolerate the high noise levels expected and which was calibrated at a simulated depth of 100 feet in compressed air.

PROCEDURE

This study was carried out subsequent to calibration of a ceramic microphone at a depth of 100 feet using the reciprocity calibration technique (White⁵; Sergeant⁶). The microphone, a General Radio P-5 ceramic microphone was then put back into the chamber and oriented in one of two ways: (a) In a horizontal plane at the approximate level of a diver's ear and facing away from the intake and exhaust valves; or (b) hanging downward at the diver's ear level at the same distance from the intake and exhaust valves as in the first condition. Figure 1 shows a diagram of the microphone positioning in the chamber. The chamber measures

*Committee on Hearing and Bioacoustics

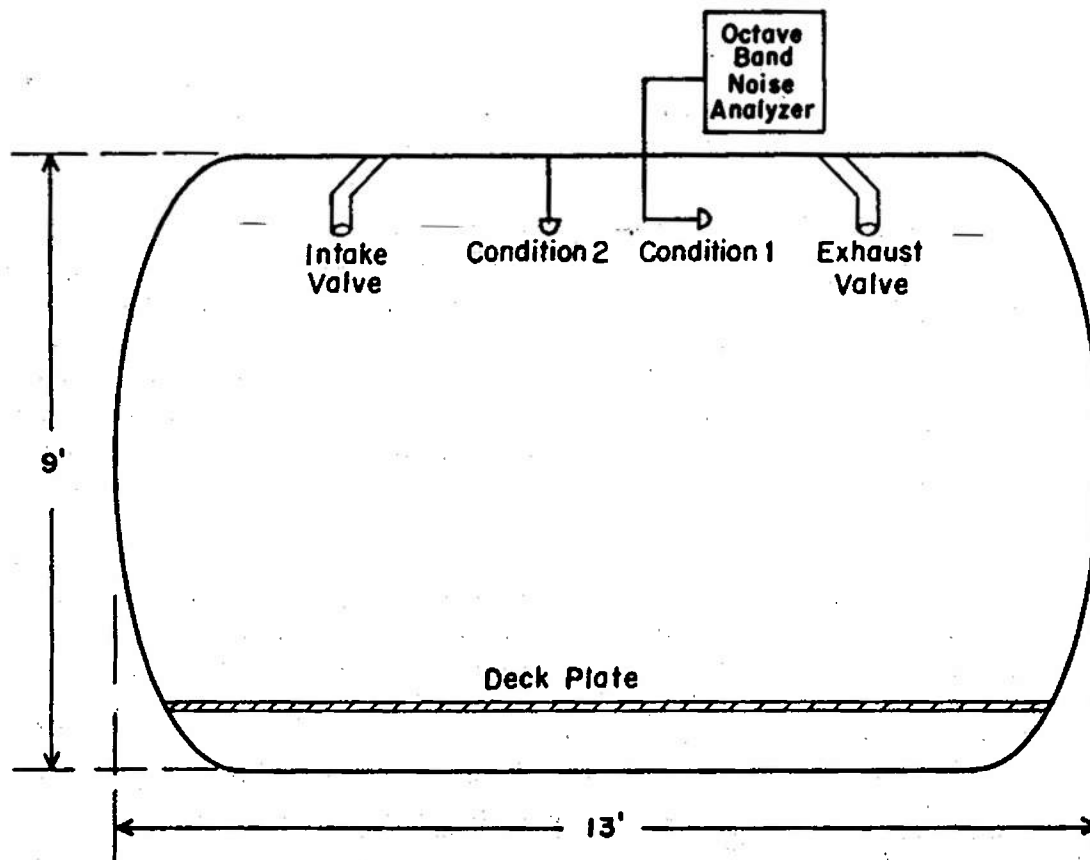


Fig. 1. Diagram of microphone positioning in hyperbaric chamber. The microphone was parallel to the deck plate in Condition 1; in Condition 2, the microphone hung downward.

9' x 13' and has a steel deck plate. The intake and exhaust valves are located overhead and directed toward the bulkhead of the metal hull. The distance of the microphone diaphragm from the deck plate was 5'6" in both conditions. A General Radio 1558-A octave band noise analyzer was located outside the chamber. Readings were taken prior to descent to 100 feet, during descent and during ascent. There was a five minute delay from the time the chamber reached 100 feet until ascent begun. The overall average rate of descent was 70 feet per minute; the average rate of ascent was 33.3 feet per minute. However, if only the ascent time from 100 to 20 feet is considered, the average

rate would be approximately 60 feet per minute. This would appear to be a more realistic value since all measures were completed by the time the chamber reached a pressure equivalent to 20 feet of sea water.

RESULTS

Figure 2 shows a graphic level recording of the noise spectra for the descending and ascending conditions with the microphone in a horizontal position. The recordings were made through a 1900-A General Radio Wave Analyzer set at a 50 Hertz bandwidth. The recordings made with the

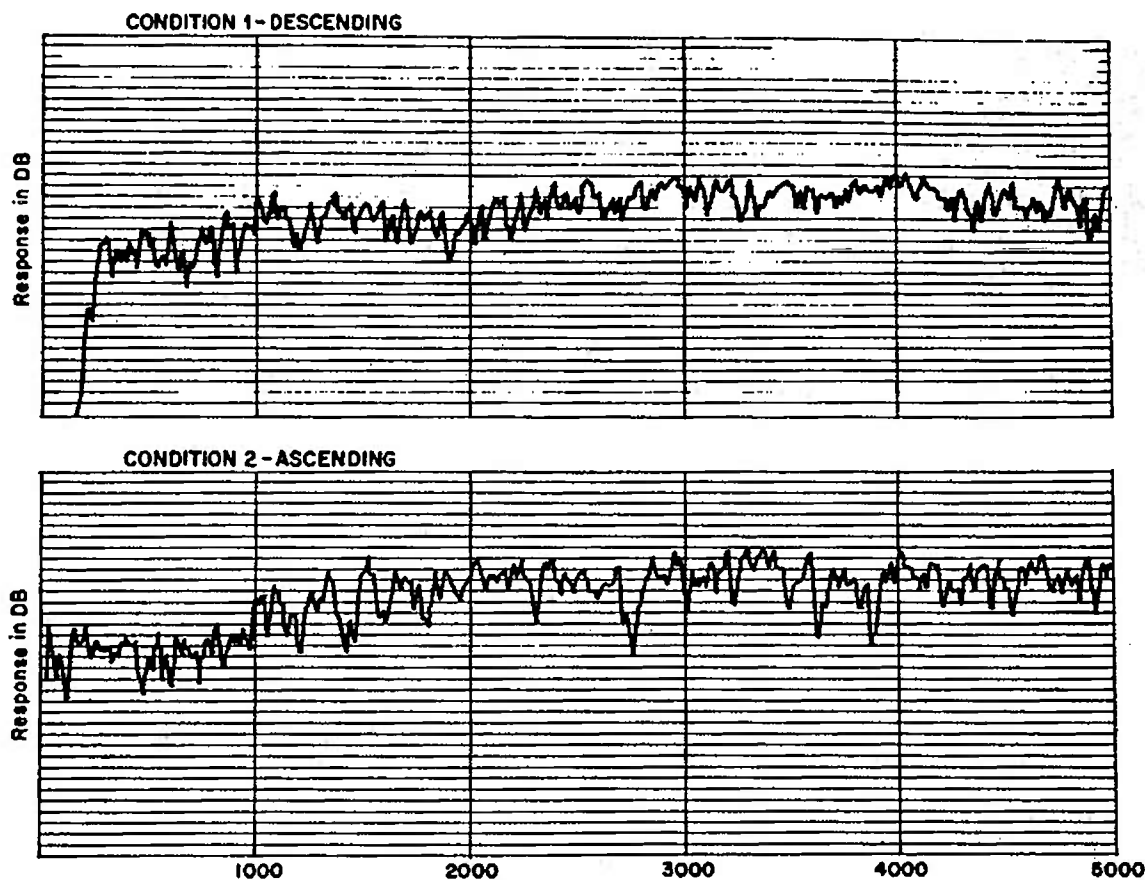


Fig. 2. Graphic level recording of noise spectra during the descending and ascending stages for Condition 1, microphone parallel to deck plate.

microphone oriented downward are quite similar. From these recordings, it would appear that the noise levels in the chamber resemble broad-band noise.

Figure 3 presents a plot of the noise levels obtained with the octave band analyzer for bands beginning at 75 Hertz. The data points within each band are the geometric mean frequencies for the bands. Figure 3 shows the descending and ascending data for Condition 1 in which the microphone was positioned parallel to the deck plate. The A-Scale reading on the octave band analyzer was 112 dB SPL during descent while during ascent it was 108 dB SPL. From Figure 3, it can be seen that the

overall band levels were approximately 6 dB greater during descent. The octave band analysis indicates that the noise levels are quite similar in shape and in their relative contribution to the overall noise level for both the ascent and descent stages. That is, the peak noise level during the descent and ascent stages was in the 2400-4800 Hertz octave band. During descent, the value was 109.5 dB SPL; during ascent, the level was measured at 103.5 dB SPL.

Figure 4 shows the octave band analysis for the second microphone positioning; that is, when the microphone was hanging downward from the ceiling of the

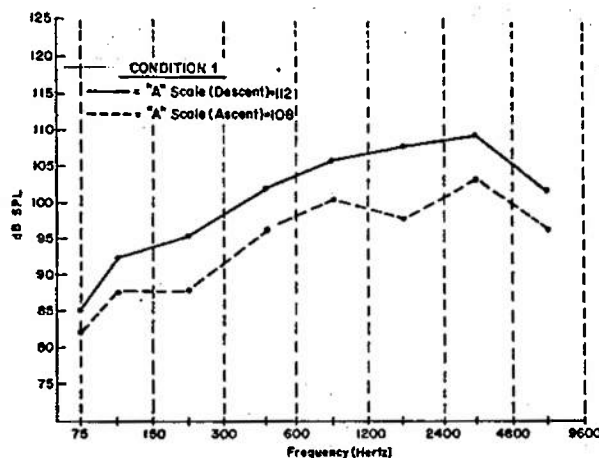


Fig. 3. Octave band noise level analysis for Condition 1. The dashed vertical lines delineate the filter boundaries. The data points are the geometric mean frequencies for each octave band.

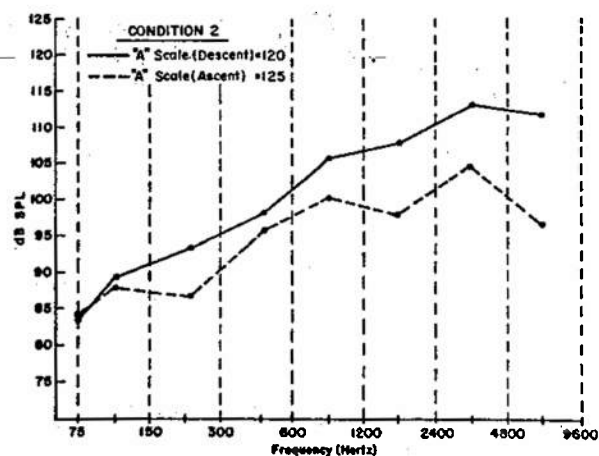


Fig. 4. Octave band noise level analysis for Condition 2. The dashed vertical lines delineate the filter boundaries. The data points are the geometric mean frequencies for each octave band.

hull. The overall A-Scale readings were 120 and 115 dB SPL, respectively, for the descending and ascending stages. The curves for the octave band analyses are similar to those in the preceeding condition and the peak noise level was again in the 2400-4800 octave. For this condition the descending and ascending stages differed by approximately 4 dB at the low-frequency bands between 75-600 Hz. In the upper three bands, the difference between the ascent and descent values was approximately 9 dB.

DISCUSSION

It is not surprising to those who have worked in hyperbaric chambers to find noise levels on the order of those

presented in this report. However, in any discussion or conclusion about such data, it must be remembered that the noise levels may vary as a function of microphone positioning, speed of descent and ascent and the amount of sound absorption material in the chamber among other things. Thus, the data in this report can only be considered exploratory in nature. Nonetheless, they do provide an indication of the noise levels which may be encountered in a chamber.

The effects of the noise levels presented in this report might be best considered by comparing the data with the 1970 damage risk criteria (DRC) of the Navy Bureau of Medicine and Surgery (7). For example, the A-Scale readings

for exposure indicate that the highest level permissible for continuous noise is 123 dB for three minutes. The present data indicate that only one value approached this cut-off point, the descent value in Condition 2. Moreover, since descent was completed in less than two minutes, this value must be considered to be within the acceptable limits. Finally, none of the measured levels for the octave bands exceeded the limits set by the Bureau of Medicine and Surgery. Thus, it can be concluded that the noise levels measured do not exceed the values specified in the DRC by the Navy. Also, since most divers make one trip per day, the recovery times from possible temporary threshold shift (TTS) would be far in excess of the required time.

A degree of caution must be exercised in deriving further conclusions or generalizations from the above data. Consider a dive to 350 feet at the rate of 70 feet per minute, a total of five minutes. If the noise level measured 120 dB SPL on the A-Scale, clearly the noise level per unit of time would be in excess of the recommended levels. Thus, there is a need to expand the present data with regard to greater depths and various speeds of descent and ascent. Another area of consideration is the diver who works in a chamber in a helmet having a free-flowing air valve which is in operation during the entire dive. The noise levels in these cases are longer in duration and closely confined to the ear. As yet, little data exists on the noise levels in various helmets.

For divers who reach depth in a short period of time, the noise levels produced by hyperbaric chambers

appear to be within the limits as specified by the Navy Bureau of Medicine and Surgery; however, it would appear that dives deeper than 100 feet may approach the DRC levels set by the Navy. Finally, it must be remembered that sufficient time must be allowed between dives for recovery from temporary threshold shift.

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